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A Variable Neighborhood Descent as ILS local search to the minimization of the total weighted tardiness on unrelated parallel machines and sequence dependent setup times

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Abstract

This paper addresses the total weighted tardiness minimization problem on unrelated parallel machines with sequence dependent setup times and job ready times. The problem consists in scheduling a set of jobs reducing the penalty costs caused by the delays in the job due dates. This is a NP-Hard problem and has been extensively studied in recent literature. In order to solve this, an ILS-VND hybrid metaheuristic is proposed, where a local search heuristic Variable Neighborhood Descent (VND) is integrated with Iterated Local Search (ILS) metaheuristic with multiple restarts. The results is compared with two state-of-art metaheuristics proposed in the literature. The statistical analysis indicates that for the most scenarios the proposed method outperforms the references metaheuristics.

Keywords: Scheduling, Unrelated Parallel Machines, Tardiness, Setup Times, Variable Neighborhood Descent, Iterated Local Search

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1 Introduction

Unrelated Parallel Machines (UPMS) environments have been extensively studied in the literature because they are very present in real manufacturing environments, such as textile industry [6], LCD display manufactory [1], ceramics industry [12], PVC pipes [4], among others. In general, these environments require setup times before the execution of each job and them are dependent on the processing sequence (Unrelated Parallel Machine Scheduling Sequence-Dependent setup time – UPMSSD). In manufacturing the contracts are often pre-established with due dates agreed with customers, the fines generated by the production delays tend to reduce profit margins and in the worst case scenario, may even lead to a breakage of these contracts.The efficiency measure for these environments is named as Total Weighted Tardiness (TWT). According to [3], another quite common feature in manufacturing processes is the jobs ready times, which determine for each job the minimum instante in time sequence in which it may be started on the scheduling.

The TWT minimization problem on UPMSSD environments with jobs ready times is studied in [8]. In this paper, a mathematical model is proposed, besides a Integrated Hybrid Metaheuristic (IHM), which integrates the ElectroMagnetism-like Algorithm (EMA) with the Apparent Tardiness Cost with Separable Setup and Ready time (ATCSSR) dispatch rule and a local search method. This approach outperforms the results achieved by the application of the Tabu Search metaheuristic showed in [9] and implementation of the Ant Colony Optimization (ACO) presented in [7].

In the current paper, in order to solve the TWT minimization problem in a UPMSSD environment with jobs ready dates, is proposed a hybrid approach integrating the Variable Neighborhood Descent (VND) and the Iterated Local Search (ILS) metaheuristic with multiple restarts. The proposed method is purchased against two state-of-art metaheuristics, IHM [8] and ACO [7]. The remain of this paper presents the following organization: In Section 2 the problem under analysis is described. The components of the proposed approach are presented in Section 3. Section 4 shows the achieved results and a analysis of them. Finally, Section 5 presents the final considerations and perspectives for future works.

2 Problem Description

The UPMSSD environment studied in this paper consists in scheduling a set $N = \{1, 2, ..., n\}$ of jobs into a set $M = \{1, 2, ..., M\}$ of unrelated and continuously available machines. Each job $j \in N$ has a processing time p_{ij}, dependent on the machine i on which it is scheduled. Two jobs must not be processed on